Aviation Operations Systems Base R&T Program

Methods for Analysis of System Stability and Safety

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http://www.aos.nasa.gov

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OUTLINE & LIST OF FIGURES

MASSS

Aviation Operations Systems Base R&T Program

List of Acronyms

Project Overview

   Goals & Objectives; Task Structure, Deliverables; Milestones

Outside Relationships

Technology Transfer

Accomplishments

Facility Utilization

Future Activities

Project Assessment

Conclusions

Summary

LIST OF ACRONYMS

MASSS

Aviation Operations Systems Base R&T Program

|	
APMS	Aviation Performance Measuring System
AQP	Advanced Qualification Program
ASRS	Aviation Safety Reporting System
AvSP	NASA's Aviation Safety Program
BASIS	British Airways Safety Information System
BMA	British Midlands Airways
CAA	UK Civil Aviation Authority
FLIDRAS	Flight Data Recovery and Analysis System
FOQA	Flight Operational Quality Assurance
GRAF	Ground Replay and Analysis Facility
ICAO	Int'l Civil Aviation Organization
ICASS	Int'l Confidential Aviation Safety System
IDEAS	Int'l Data Exchange for Aviation Safety
KLM	Royal Dutch Airlines
NAS	National Aviation System
NAOMS	National Aviation Operational Monitoring System
NRL	Naval Research Laboratory
NTSB	National Transportation Safety Board
QUORUM	Quantitative, Objective, Representative, Unambiguous Modeler
SAA	NASA Space Act Agreement
SESMA	British Airways' Special Event Search and Master Analysis
UAL	United Airlines

GOALS and OBJECTIVES

GOAL

Provide the tools for understanding the total aviation system from the baseline perspective (what is happening today) and from the perspective of future changes to the system.

The Operational Pyramid

Fatal

Accidents

Incidents

Normal Operations
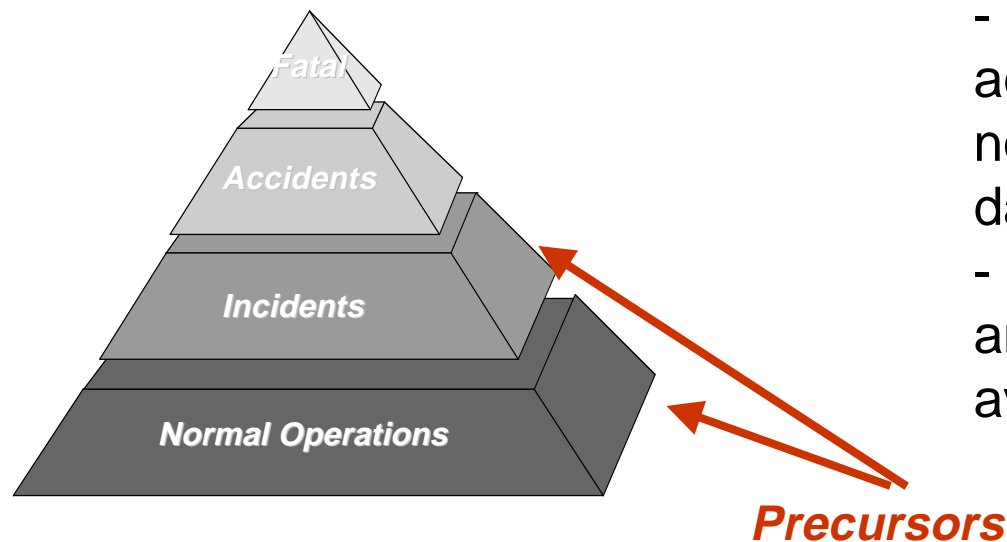
Precursors

Objectives:
- Identify causal factors, accident precursors and off-nominal conditions in aviation data
- Provide health, performance, and safety information to aviation decision makers.

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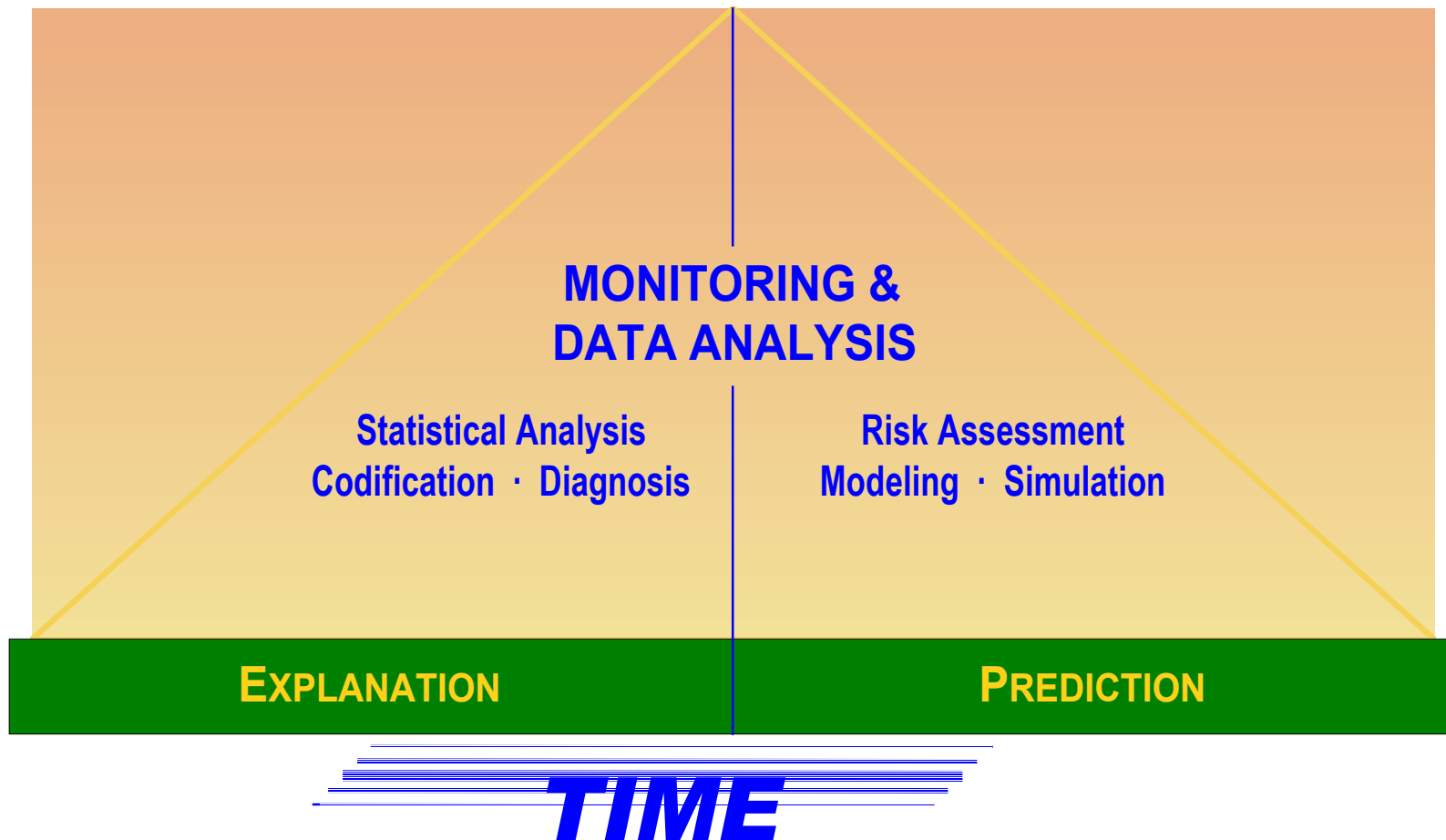
MASSS Approach to Assessment of System Safety

Data Analysis Task Structure

Aviation Operations Systems Base R&T Program

Data Analysis Tools

> **Taxonomy Development and Support**
>
> **Automated Analyst Advisor**
>
> **Machine Comprehension of Text**
>
> **Database Linkage**
>
> **Data Mining**
>
> **Causal Analysis**
>
> **Risk Assessment**

Data Analysis Extensions

> **Air Carriers Assessment**
>
> **ATC Assessment**

Monitoring Task Structure

ASRS Extensions

    Incident Reporting Enhancements (ASRS) -

      Infrastructure Upgrades

      Electronic Submission of Reports

NAS Operational Monitoring

    NAOMS -

      Prototype and Trial

      Infrastructure Development

      Implementation

Modeling and Simulation

    Human Factors Integration into Models

    Simulation*

Real-time Demonstration*

    ***Planned for out years in AvSP**

DELIVERABLES

Aviation Operations Systems Base R&T Program

- *<u>Data analysis</u> capabilities to facilitate analysis of relevant data to identify causal factors, accident precursors, and unexpected features in the data collected pertaining to health, performance and safety of the NAS.*

FY98
  APMS flight-operations tools adapted to GRAF & A-320
  Knowledge-based automated search for atypical flight
  Workshop on taxonomies

FY99.
. "Bridging" taxonomy (taxonomies) for databases
  Data analysis tools to support training and maintenance planning
  PC-based animation with acceptable fidelity for $15K.

DELIVERABLES *cont'd*

System-wide <u>monitoring and modeling</u> methodologies and tools to monitor continuously the operational performance and health of the National Aviation System and the impact of any changes to the system.

FY98

  Upgraded ASRS database

  Specifications for 1st build for ATM of adapted APMS tools

  Design of NAOMS protocol for focused trial

FY99

  A reliably secure capability to submit reports to ASRS on the Web

  Demo of survey system in a focused trial.
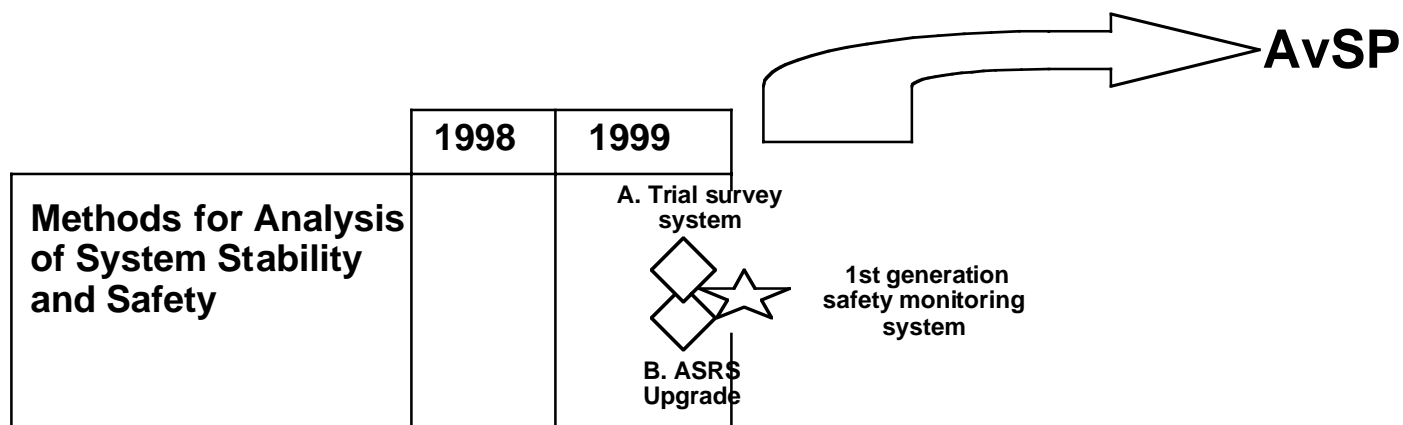
  Algorithms for ATM applications

  Limited-scope model for risk assessment

<div style="border: 1px solid red">

Level 1 Milestone: Develop a 1st generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance (FY99).
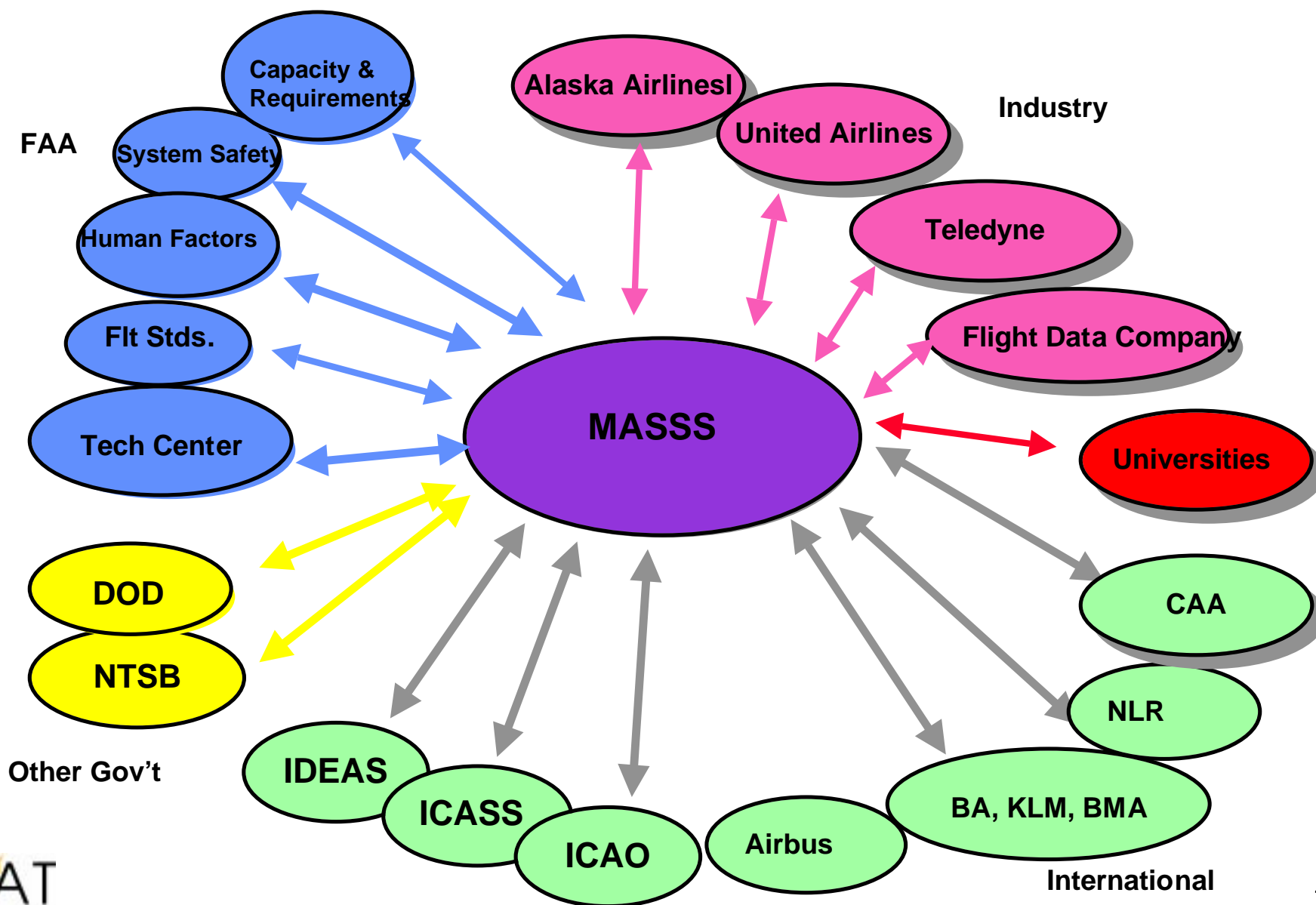
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Level 2 Milestones (AOS)

AvSP

	1998	1999
Methods for Analysis of System Stability and Safety		A. Trial survey system
		B. ASRS Upgrade

1st generation safety monitoring system

- **A. Implement focused trial project of survey system and create 1st generation causal database using advanced coding taxonomies and coding processes (FY99).**

- **B. Upgrade ASRS with 1st generation causal database (FY99).**

Outside Relationships

MASSS

Aviation Operations Systems Base R&T Program

FAA

Capacity & Requirements

System Safety

Human Factors

Flt Stds.

Tech Center

Industry

Alaska Airlinesl

United Airlines

Teledyne

Flight Data Company

MASSS

Universities

DOD

NTSB

Other Gov't

IDEAS

ICASS

ICAO

Airbus

BA, KLM, BMA

NLR

CAA

International

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TECHNOLOGY TRANSFER

Aviation Operations Systems Base R&T Program

Product	Requirements	Commercialization Agreements	Collaborating Partners/Customers
APMS VIEWER	Analyst-friendly interface for examining flight data	The Flight Data Company, Ltd	Alaska Airlines, UAL, KLM, BMA
APMS REPORT GENERATOR	Automated aid to reporting special events & exceedances	The Flight Data Company, Ltd	Alaska Airlines, UAL, KLM, BMA
APMS EPS	Automated knowledge-based aid for tracking and verifying special events & exceedances	The Flight Data Company, Ltd (Patent Pending)	Alaska Airlines, UAL, KLM, BMA
APMS ANIMATION LINK	Automated link from data to PC-based animation	Coryphaeus Software & SimAuthor	Alaska Airlines & UAL
APMS PATTERN SEARCH	Automated knowledge-based search for prescribed pattern	Teledyne Controls, Inc	Alaska Airlines & UAL
APMS SVD	Automated identification for atypical data	Teledyne Controls, Inc	Alaska Airlines & UAL
TAXONOMY	Internationally standardized taxonomy for codifying data		FAA, NTSB, ICAO, IATA, etc

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MAJOR ACCOMPLISHMENTS (FY 98)

Aviation Operations Systems Base R&T Program

Demonstrated 3rd build of APMS tools, Level 1 Milestone, 4th Q, '99
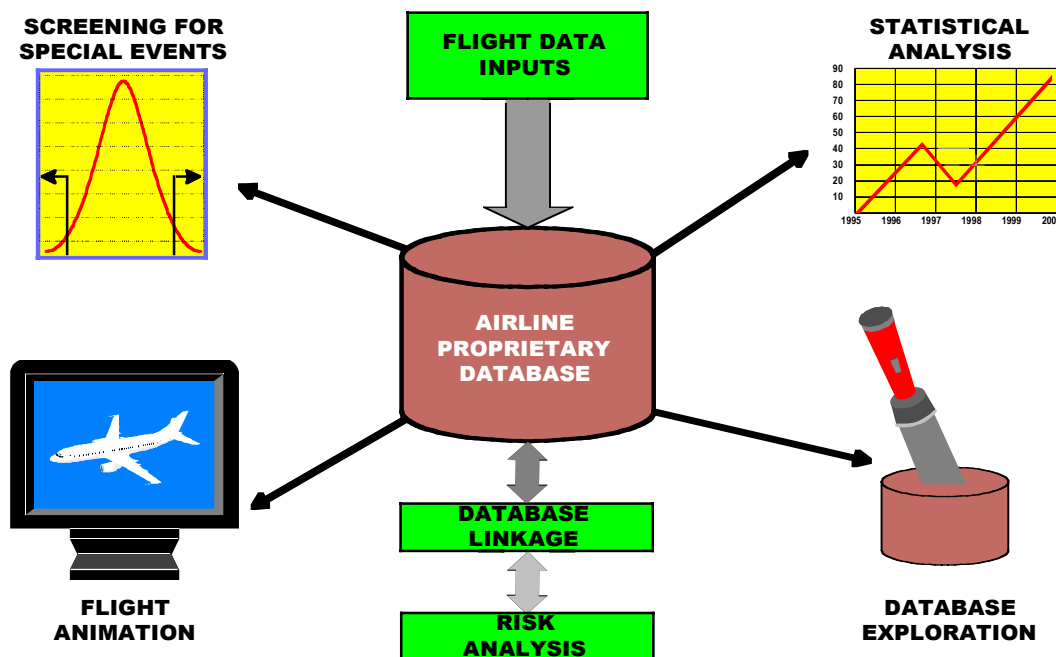
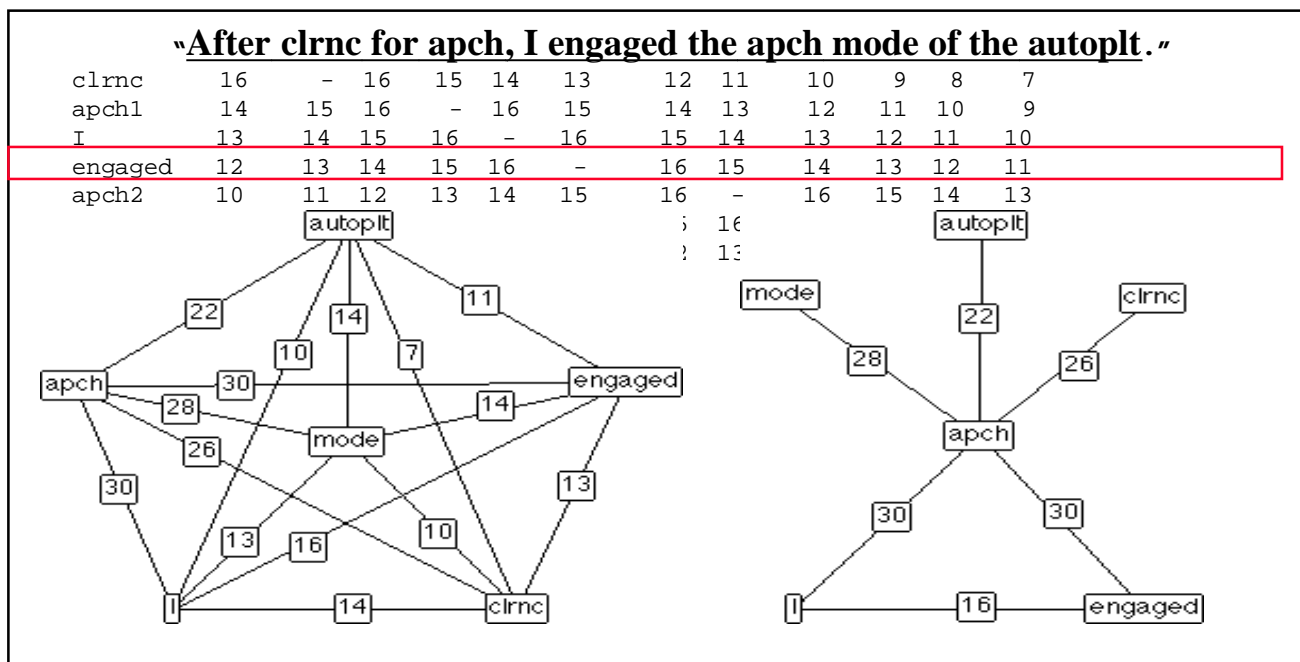**APMS 3rd build declared operational at Alaska Airlines.
Being used on 6 MD-80s using FLIDRAS**

MAJOR ACCOMPLISHMENTS (FY 98)

Aviation Operations Systems Base R&T Program

Demonstrated the use of QUORUM in comparison with expert human analysts, Level 2 Milestone, 4th Q. 01.

"After clrnc for apch, I engaged the apch mode of the autoplt."

clrnc	16	–	16	15	14	13	12	11	10	9	8	7
apch1	14	15	16	–	16	15	14	13	12	11	10	9
I	13	14	15	16	–	16	15	14	13	12	11	10
engaged	12	13	14	15	16	–	16	15	14	13	12	11
apch2	10	11	12	13	14	15	16	–	16	15	14	13

Used the QUORUM system of machine readable text to automatically aid the process of relating NTSB accident reports and ASRS Incident reports

OTHER ACCOMPLISHMENTS (FY98)

Data Analysis

- APMS database architecture redesigned in ORACLE for UAL

- Demonstrated 1st APMS at UAL (40 A-320s)
- Simulator data processed with APMS
- Conducted industry/government Data Analysis workshop
- Made selections from ~30 proposals received in response to Data Analysis offering

Monitoring and Modeling

- Completed study of the demographics of the NAS; conducted 2 initial studies with pilots, one with ATC's in support of the NAOMS.
- Conducted NASA/government/industry taxonomy workshop.
- Upgraded ASRS database to ORACLE.
- Conducted industry/government Monitoring workshop.
- Made selections from ~25 proposals received in response to Modeling offering.

Aviation Operations Systems Base R&T Program

MASSS Facility Utilization

Aviation Operations Systems Base R&T Program

NASA ASRS Development Laboratory

NASA APMS Development Laboratory

NASA Advanced Information Systems Laboratory

UAL GRAF Installation, Flt. Safety & Procedures

Alaska FLIDRAS Installation, Flt. Safety & Procedures

Teledyne - FLIDRAS Development. Facilities

Flight Data Company - GRAF Development Facilities

ATAC - Radar Tracking Data Development Facility (ATC extension)

Battelle Facilities (Ogden, Utah and PNWD, Richland, WA)

SimAuthor - PC-based animation Development Facility (FY99)

ATC Facilities - Six on the North/South CA coast (FY 99)

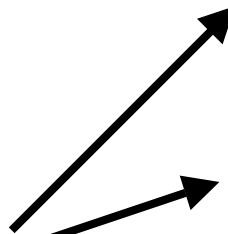*Aviation Operations Systems Base R&T Program*

FY 00 and Beyond

AOS

AvSP

Data Analysis → **Data Analysis Tools and Intramural Modeling**
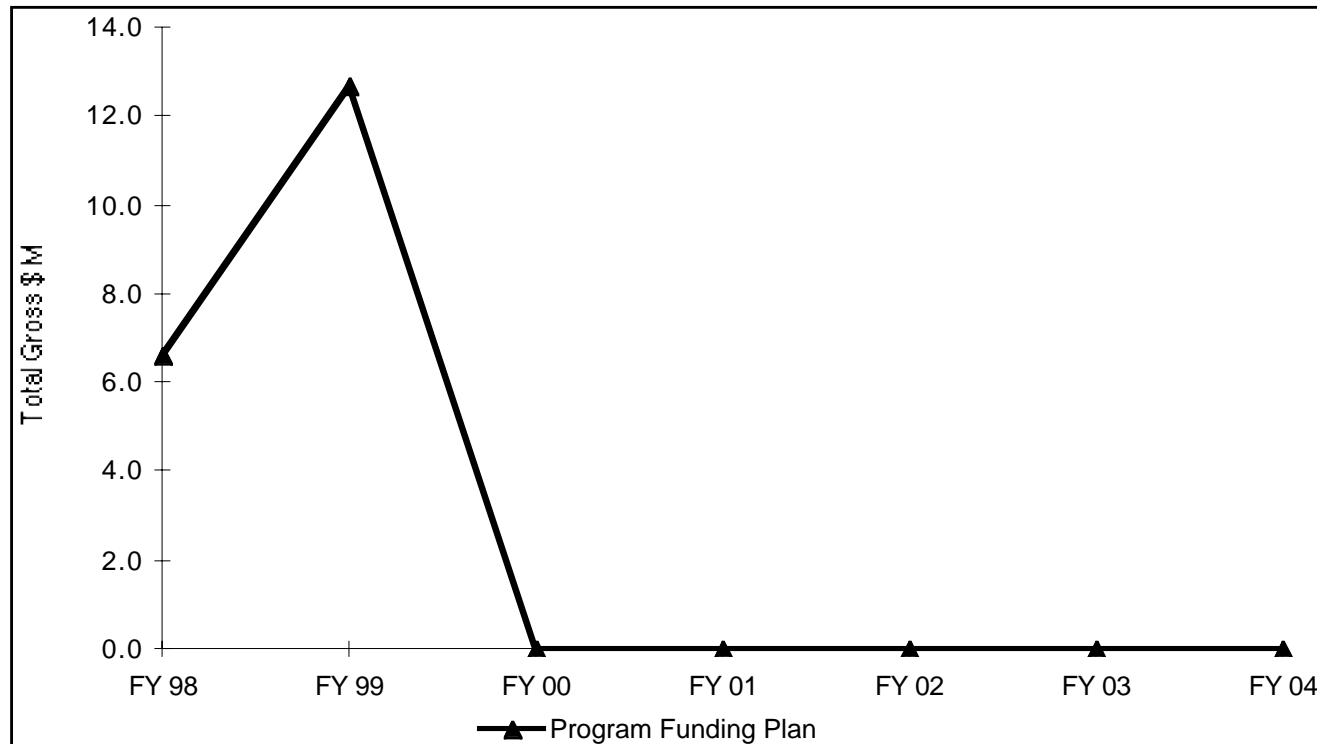
Monitoring and Modeling → **Extramural Monitoring**

Modeling & Simulation

PROJECT FUNDING PLAN

Methods For Analysis Of System Stability & Safety (MASSS)

Aviation Operations Systems Base R&T Program

Program Funding Plan	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	Total
Net Totals	4.5	8.3	0.0	0.0	0.0	0.0	0.0	12.8
Program Support	2.1	4.4	0.0	0.0	0.0	0.0	0.0	6.5
Total (Gross)	6.6	12.7	0.0	0.0	0.0	0.0	0.0	19.3

Project Assessment

Aviation Operations Systems Base R&T Program

	3Q98	4Q98	1Q99	Remarks
Project Overall Assessment	G	G	G	
Technical Performance	G	G	G	
Cost	G	G	G	
Schedule	G	G	G	

Guidance:

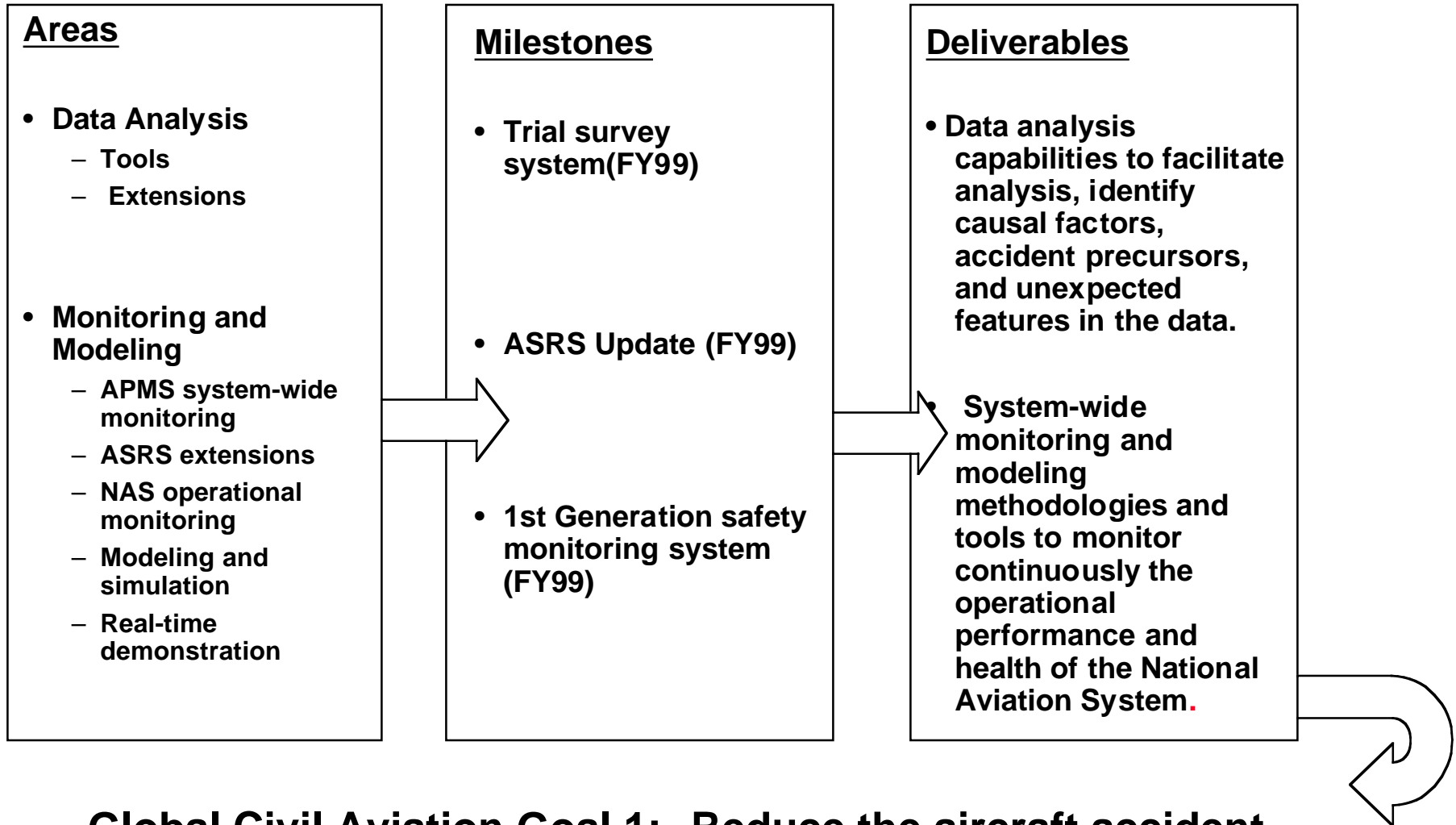|	
Assessment & Performance	L2 Judgement
Cost	-5% Yellow -15% Red
Schedule	-1Q Yellow -2Q Red

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Conclusions

MASSS includes base technology development that has already achieved significant industry participation and safety operations successes.

MASSS supports the development of capabilities to proactively manage the aviation system. This represents a conceptual shift from approaches presently in use.

Aviation Operations Systems Base R&T Program

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SUMMARY

Aviation Operations Systems Base R&T Program

Areas

- **Data Analysis**
  - Tools
  - Extensions

- **Monitoring and Modeling**
  - APMS system-wide monitoring
  - ASRS extensions
  - NAS operational monitoring
  - Modeling and simulation
  - Real-time demonstration

Milestones

- **Trial survey system(FY99)**

- **ASRS Update (FY99)**

- **1st Generation safety monitoring system (FY99)**

Deliverables

- Data analysis capabilities to facilitate analysis, identify causal factors, accident precursors, and unexpected features in the data.

- System-wide monitoring and modeling methodologies and tools to monitor continuously the operational performance and health of the National Aviation System.

Global Civil Aviation Goal 1: Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 20 years.

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Aviation Operations Systems Base R&T Program

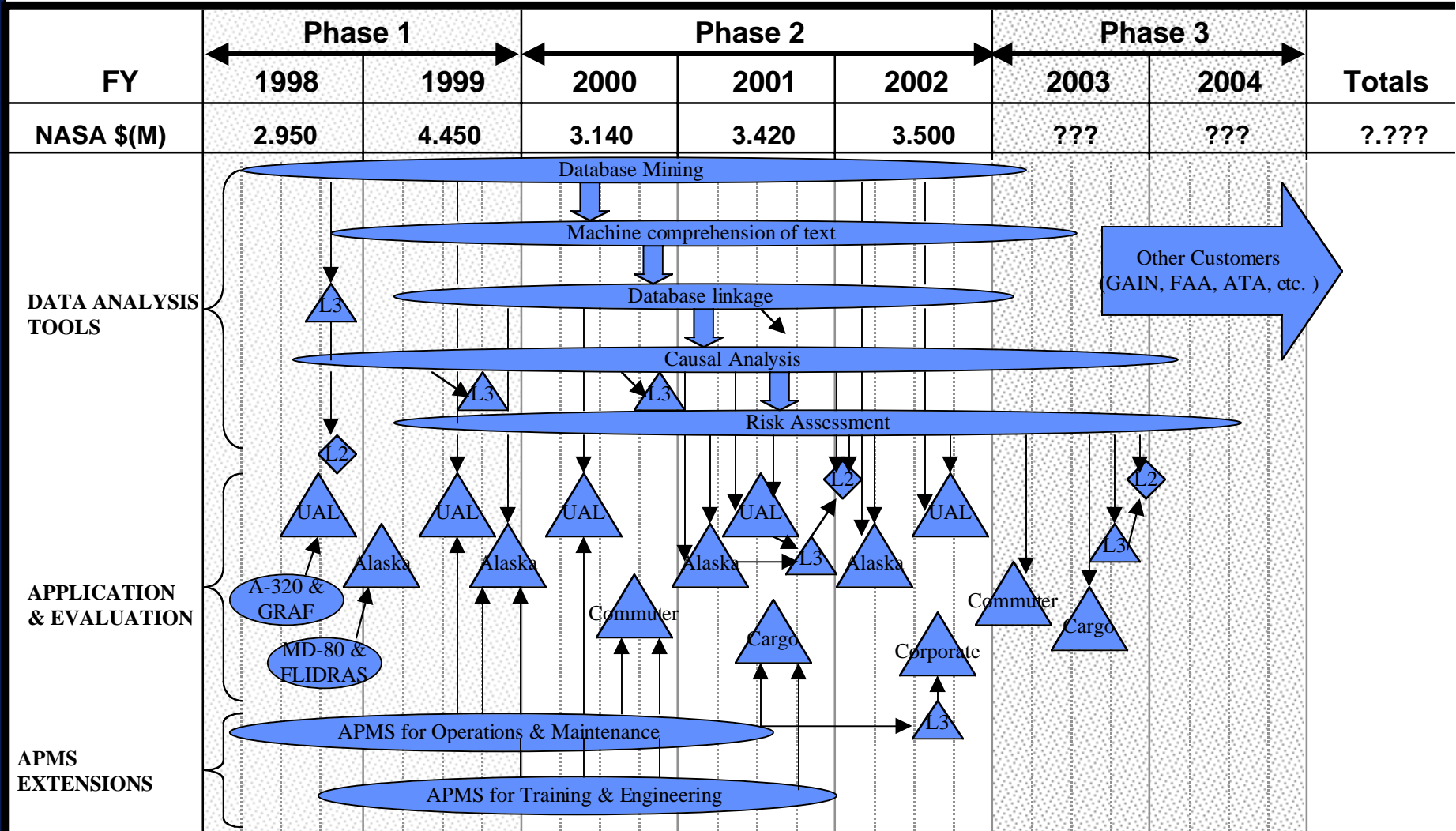# Backup Slides

FUTURE FY 99 Activities

Data Analysis
- Implement collaboration among ARC, LeRC, and Pratt and Whitney on knowledge-based system for monitoring engine health.
- Collaborate with FAA, Flight Safety Foundation, Sandia Labs, and Rannoch Corp. on models for risk assessment.
- Develop exploration tools

Monitoring and Modeling
- Collaborate with Dodd Asso., Center for Public Health Research and Evaluation and the Joint Project for Survey Methodology to develop statistical design for the NO AOMS survey.
- Continue to engage the aviation community in the design of the survey system.
- Implement collaboration with the FAA to extend APMS to ATC for performance monitoring and to demonstrate the concept in a sector of the ATC.
- Establish performance metrics and measuring techniques for evaluating COTS capabilities for real-time monitoring in a flight experiment.

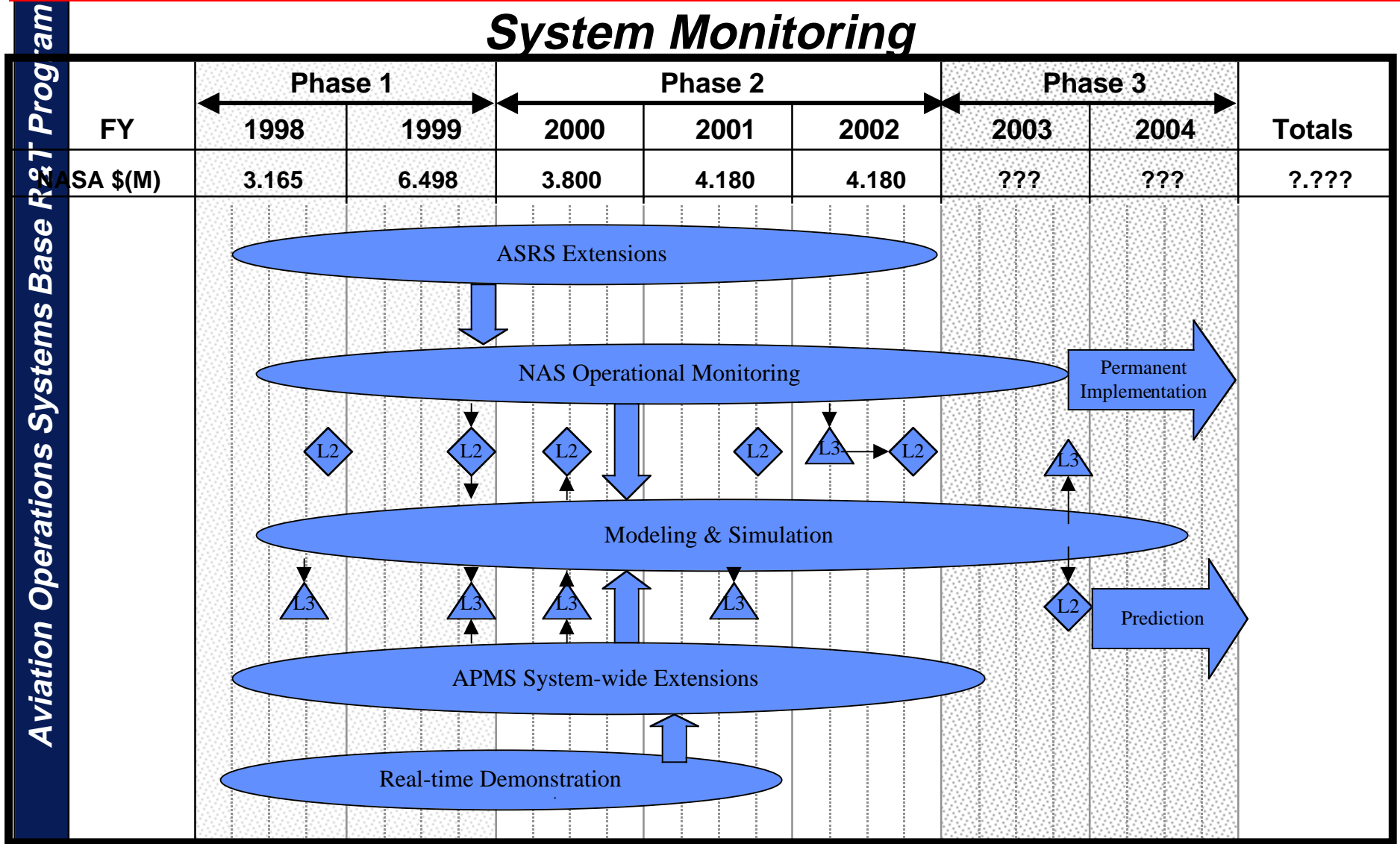# System-wide Monitoring & Modeling

MASSS

Aviation Safety Program / Non-Advocate Review

Data Analysis

Aviation Operations Systems Base R&T Program

		Phase 1		Phase 2			Phase 3		
FY		**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Totals**
NASA $(M)		2.950	4.450	3.140	3.420	3.500	???	???	?.???

DATA ANALYSIS TOOLS

Database Mining

Machine comprehension of text

Database linkage

Causal Analysis

Risk Assessment

Other Customers (GAIN, FAA, ATA, etc.)

L3

L3 L3

L2

APPLICATION & EVALUATION

L2

UAL UAL UAL UAL UAL

Alaska Alaska Alaska L3 Alaska

A-320 & GRAF

MD-80 & FLIDRAS

Commuter Commuter

Cargo Cargo

Corporate

L3 L2

APMS EXTENSIONS

APMS for Operations & Maintenance L3

APMS for Training & Engineering

◇ **n** L2 Deliverable   △ **m** L3 Milestone   ○ Decision Pt.   ● Darkened symbols denote complet

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Aviation Safety Program / Non-Advocate Review

System Monitoring

FY	Phase 1		Phase 2			Phase 3		Totals
	1998	1999	2000	2001	2002	2003	2004	
NASA $(M)	3.165	6.498	3.800	4.180	4.180	???	???	?.???

◇ₙ L2 Deliverable   △ₘ L3 Milestone   ○ Decision Pt.   ⬤ Darkened symbols denote completion

Aviation Operations Systems Base R&T Program

Level 2 Milestones (AvSP)

	2000	2001	2002	2003	2004
Methods for Analysis of System Stability and Safety	◇ A. APMS to ATC	◇ B. Merge heterogeneous databases	◇ C. Add GA/NAOMS	◇ D. Fast-time sim of risk	◇ E. Modeling to replicate NAOMS

A. Demonstrate application of APMS concepts and methodologies to ATC for performance monitoring (Mar '00).

B. Demonstrate, in operational environments, tools for merging heterogeneous databases to aid causal analysis and risk assessment (Sep '01).

C. NAS Operational Monitoring Service adds the GA pilot community to the survey (Sep. '02).

D. Demonstrate capability of fast-time simulation for reliable prediction and assessment of system-wide risk (Sep. '03)

E. Demonstrate capabilities of modeling and simulation to replicate and validate hypotheses based on reports from the NAS Operational Monitoring Service (Mar '04).

Aviation Operations Systems Base R&T Program

FY 00 and Beyond

AOS

AvSP

Data Analysis

Data Analysis Tools
Extension of Data Analysis
Algorithms

Data Analysis Tools and Intramural Modeling

Monitoring and Modeling

APMS System-Wide Extensions
ASRS System-wide Extensions
NAS Operational Monitoring
Modeling and Simulation

Extramural Monitoring

Modeling & Simulation

Outside Relationships

FAA

- **Agreements with Office of System Safety, Flight Standards, and the Human Factors Research Division.**
- **Collaboration with Aviation Safety Division of the Tech Center (applying data analysis tools to maintenance); Office of System Capacity and Requirements (adapting data analysis tools to Air Traffic Management.)**

Other Government

- **NTSB, DOD**

Industry

- **SSA's with United A/L, Alaska A/L, Flight Data Company, and Teledyne**

International

- **Participation in IDEAS conference (maintenance safety data; sharing with other nations)**
- **Continued participation in the International Confidential Aviation Safety Systems Committee on implementing voluntary safety reporting systems.**
- **Continued collaboration with key international partners (ICAO, SITA, Airbus, CAA, BA, KLM, BMA, NLR.)**